ORAL PRESENTATIONS

POSTERS

1. Application of Machine Learning in Air Quality Modeling for Bangladesh Considering the Effect Of COVID-19 Restrictions
2. Investigating Stability of BVOC-Derived Secondary Organic Aerosol with Respect to Hydrolysis and Photolysis
3. Improving UI-WRF-Chem simulation of surface aerosol diurnal variation in the United States through ground-based and satellite observations
4. Quantifying Impact of Organic Films on Cloud Condensation Nuclei Activity
5. Studying Air Quality in South Korea using Chemical Transport Modeling and Satellite Data
6. Using Particle-resolved Aerosol Model Simulations to Determine the Hygroscopicity and Mixing State of Aerosols in Dynamic Chemical Reactors.
7. Improving the ability of air quality models to capture N2O5 heterogeneous chemistry
8. Characteristics of Interannual Variability in Space-based XCO2 Global Observations
9. Overview of meteorology and chemistry of ozone episodes during the Lake Michigan Ozone Study 2017
10. Pittsburgh and Air Pollution: A Study of Criteria Gases and Particulate Matter During the COVID-19 Lockdown
11. PyPartMC: a Pythonic Interface to a Particle-Resolved Monte-Carlo Aerosol Simulation Framework
12. Learned acceleration of 1-D passive scalar advection for atmospheric modeling
13. Learning the Pattern Effect Using Model-Data Fusion: Observationally Constrained Green's Functions in a Hierarchical Bayesian Framework.
14. Evaluating the Skill of Linear Models of Salinity and δ18OSW Using Isotope-Enabled Climate Models
15. Change in the frequency of tornado activity in China due to climate change
16. Effects of Increasing Climate Variability on Human Health: A Case Study of Mosquitoes from Stormwater Infrastructure in Central Illinois
17. The impacts of different building materials on nearby temperatures in the summer season in Raleigh, NC
18. Impacts of Ecological Drought on Terrestrial, Aquatic, and Avian Species in Ohio
19. Inventory of Federal Climate Engagement and Capacity-building Programs
20. Generating High Resolution Daily Soil Moisture by Applying Machine and Deep Learning
21. Alterations in Land-Ocean Parameters by Considering Atmospheric Meteorology Associated with Tropical Cyclone "Tauktae".
22. Python Development for Unstructured Mesh Analysis & Visualization

23. Multiscale Characteristics within Tropical Easterly Waves That Are Crucial for Tropical Cyclogenesis over the Atlantic
24. Preliminary Analysis of the 1800 UTC 01 February- 0000 UTC 06 February Frontal System Sampled Twice by IMPACTS
25. Synoptic Analysis of Two 14-Day Extreme Precipitation Events in the Northwestern United States
26. Examining the Effects of Shear-Generated Turbulence within Kelvin-Helmholtz Waves in Mountainous Terrain on Microphysical Processes using Radar Range Height Indicator Scans
27. A Spatial Analysis of Ohio CoCoRaHS Stations
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30. Preliminary Categorization of 2020 and 2022 IMPACTS Cyclones for the Analysis of Wintertime Cyclones from a Satellite Perspective
31. Diagnosis of Arctic Cyclone Structure and Comparison with Midlatitude Cyclones
32. Analysis of Energy Regime Transitions above the Southern Ocean
33. Observations of the macrophysical properties of cumulus cloud fields over the tropical western Pacific
34. Retrieving 3D Volumetric Properties of Clouds from Multi-Angle Imagery
35. Satellite-observed changes of surface reflectance, emissivity, and temperature due to solar farming and the implication for radiation budget
36. On the radar detection of cloud seeding effects in wintertime orographic cloud systems
37. The Prediction of Potential Tornado Intensity Using Machine Learning
38. Increased Tornado Activity in Illinois During Severe Weather Off-season
39. Understanding the Impact of the Lower Stratospheric Thermodynamic Environment on Observed Overshooting Top Characteristics
40. Physical-Chemical Characterization of Hailstones Collected near Córdoba, Argentina
41. Numerical Simulations of Cloud Droplet Temperatures in Sub-saturated Environments
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ORAL SESSION I: SATURDAY, OCTOBER 1 | 9:45 AM –10:45AM

A Continuing Review of the "Tornado Possible" Tag in NWS Severe Thunderstorm Warnings

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Since April 1, 2015, National Weather Service (NWS) meteorologists have had the option of including a tag of "tornado possible" within the text of a severe thunderstorm warning indicating the potential of a tornado to form with difficulty in radar detection and subsequent limited lead-time. However, only general guidance was provided to forecasters, resulting in inconsistent usage of the tornado possible tag amongst NWS offices, even offices that neighbor one another. This study analyzes the "tornado possible" tag usage by two other WFOs: Nashville, TN and Grand Rapids, MI. The Grand Rapids WFO was chosen due to the high tag usage rate of 27% compared to surrounding offices. The Nashville WFO was chosen due to having a relatively average tag usage rate of 6% and for being environmentally comparable to the Huntsville WFO region, where a previous study on "Tornado Possible" tag usage was conducted. Analyses for environmental parameters commonly used by forecasters in warning decisions were made for each usage of the tornado possible tags. This allows greater insight into the data used by the warning forecaster when choosing the use of the tag over the issuance of a tornado warning. Overall, it was found that, at both WFOs, most "tornado possible" tags were used during linear convective storm modes, with all of the tornadoes produced within the "tagged" areas being classified as "weak". Additionally, there were not large differences in the average severe weather environmental parameters during "tagged" events between the WFOs. This study is designed to be easily replicable for other WFOs in order to provide an objective analysis and identify best practices regarding the usage of the "Tornado Possible" tag across the NWS.

Case Study of the Extreme High-Shear, Low-CAPE, Strongly-Forced Tennessee Valley QLCS of 12 February 2020

Adam Weiner[1], Kevin Knupp[1], Lawrence Carey[1], and John Mecikalski[1]
[1] *University of Alabama in Huntsville, Department of Atmospheric and Earth Science*

High-shear, low-Convective Available Potential Energy (CAPE) environments present unique operational forecasting challenges every year during the cool season across the southeastern United States. With weak instability and strong vertical wind shear, these severe weather events typically require a strong forcing mechanism to develop and sustain deep convection. This case study investigates a severe weather event from 12 February 2020, where 200-300 J kg-1 of CAPE and 0-1 km shear magnitude around 25 m s-1 in tandem with strong low-level forcing induced by a gust front resulted in a Quasi-Linear Convective System (QLCS) whose severe weather was difficult to anticipate. Across northwestern Alabama and southern Middle Tennessee, this QLCS produced fifteen severe weather reports, including two weak (EF-1 and EF-0) tornadoes and one 76 mph (34 m s-1) wind gust, without any warnings in effect during its first hour of severe weather production. Careful examination of surface observations revealed the primary forcing mechanism as a cold pool originating in Louisiana. A study of the QLCS's evolution using dual-polarization radars determined the system featured both slabular and cellular structures throughout much of its life, with severe weather primarily occurring within the transition zone between these two regimes. In addition, preliminary findings from dual-Doppler wind retrievals indicate a maximum updraft magnitude of around 10-15 m s-1 centered approximately 4 km above ground within severe bow echoes. Interestingly, preliminary dual-Doppler wind retrievals also suggest that a long-lived mesovortex, which produced several swaths of severe weather during this event, featured a persistent downdraft of up to 8 m s-1 approximately 4 km above ground at the center of circulation. Key findings from the dual-Doppler analyses along with a quantification of boundary layer variability preceding the QLCS utilizing a mesoscale network of surface observing stations, wind profilers, and balloon soundings will be presented.

ORAL | POSTER

Investigating the Development and Characteristics of Streamwise Vorticity Currents in Simulated Supercell Thunderstorms

Kevin Gray[1] and Jeffrey Frame[1]

[1] *University of Illinois at Urbana-Champaign, Department of Atmospheric Sciences*

Streamwise vorticity currents (SVCs) have recently been hypothesized to enhance low-level mesocyclones within supercell thunderstorms and perhaps increase the likelihood of tornadogenesis. Recent observational studies have confirmed the existence of SVCs. A suite of 19 idealized supercell simulations, all exhibiting SVCs, is analyzed to determine how SVC formation and characteristics may differ between storms. SVCs develop along the left-flank convergence boundaries in the simulated supercells and their updraft-relative position varies with the internal outflow surge location. Vorticity budgets calculated along trajectories initialized within the outflow surges associated with SVCs reveal that baroclinic generation of horizontal vorticity occurs as air descends in downdrafts. If the baroclinically-generated horizontal vorticity is not already streamwise, it is reoriented through tilting or crosswise-to-streamwise exchange. The streamwise vorticity is then stretched as the air accelerates toward the updraft where it is tilted upward and the vorticity is stretched vertically. This process is identified in a representative subset of the 19 simulations. The depth of SVCs varies with outflow surge location owing to differences in outflow propagation in shear, but the general shape and dimensions of SVCs are consistent with previous findings. Lastly, many of the tornado-like vortices in the simulations are preceded by SVCs, supporting the hypothesis that SVCs may increase the likelihood of tornadogenesis by strengthening low-level mesocyclones.

ORAL | POSTER

Signatures of QLCS Tornadogenesis in Overshooting Tops and Upper-Tropospheric Radar Reflectivity

Edward C. Wolff IV [1], Robert J. Trapp[1], and Stephen W. Nesbitt [1]

[1] *University of Illinois at Urbana-Champaign, Department of Atmospheric Sciences*

Tornadoes that form from quasi-linear convective systems (QLCSs) are especially difficult to predict and identify, leading to lower situational awareness and shorter warning lead times. QLCS tornadoes are especially prevalent in the Southeast United States and societal factors within this region make these tornadic QLCSs especially devastating to the communities they impact. It is hypothesized that stronger, severe (either tornadic or damaging wind-producing) circulations that strengthen more rapidly tend to be associated with overshooting convection with wider overshooting tops, whereas weaker, non-severe circulations are not. To address this hypothesis, local storm reports and storm surveys during the four Intensive Observing Periods of the 2022 Propagation, Evolution, and Rotation in Linear Storms (PERiLS) field campaign are used to identify low-level circulations within QLCSs that are then classified as tornadic, damaging wind-producing, or non-severe. These circulations are then compared to upper-tropospheric features, such as overshooting tops (OTs), which are calculated with an OT identification algorithm using 1-minute resolution mesoscale sector data from the GOES-16 satellite, as well as strong updrafts, identified with multi-radar multi-sensor (MRMS) 3D mosaic reflectivity products. Preliminarily, only a fraction of tornadoes within a QLCS exhibit robust updrafts, even when their surface circulations are of a similar duration and magnitude. Controls of updraft characteristics in QLCSs are also explored. The identification of updraft and tornadogenesis signatures within high-resolution geostationary satellite and MRMS data may ultimately help improve the process used to nowcast damaging QLCSs.

ORAL | POSTER

Evaluating the Predictability of QLCSs and Embedded Tornado-like Vortices using the HRRR

Leanne Blind-Doskocil[1], Robert J. Trapp[1], and Stephen W. Nesbitt [1]
[1] University of Illinois at Urbana-Champaign, Department of Atmospheric Sciences

The predictability of tornadoes spawned by quasi-linear convective systems (QLCSs) is a long-standing forecasting challenge. They often develop in as little as 5-10 minutes and lack long-lead-time radar signatures, making it difficult to anticipate where the greatest tornado threat will occur. This preliminary research investigates whether the hourly updated High-Resolution Rapid Refresh (HRRR) atmospheric model, with 3 km horizontal grid spacing, can predict tornado-like vortices (TLVs) within cool-season QLCSs 18, 12, and 6 hours prior to tornadogenesis. Using a previously developed QLCS database, this research examines 93 cool-season QLCS tornado cases identified in radar observations during 2019. From this database, the closest QLCS simulated by the HRRR to an observed QLCS tornado 18, 12, and 6 hours prior to tornadogenesis was identified with the criteria of having a closed 35 dBZ simulated composite reflectivity contour of at least 100 km in maximum dimension. Out of the 93 cases, the HRRR exhibited a QLCS in all cases for forecast hours 18 and 12 and in all but one case for forecast hour 6. The closest simulated QLCS to the observed tornado for each case and forecast hour were considered to be matched if the tornado was within 50 km of the closest QLCS. The 18-hour forecasts had the highest match percentage (65%), followed by the 6 and the 12-hour forecasts at 59% and 50% respectively. For the cases and forecast hours that the HRRR represented a QLCS within 50 km of the observed tornado, different strategies for quantifying rotation within the modeled QLCS are tested, including using maximum 2-5 km updraft helicity (UH) values to determine whether the HRRR can produce TLVs within QLCSs. Continuing work examines whether varying the levels of computation for maximum UH values (i.e., 0-2 km vs 2-5 km) improve the quantification of HRRR-predicted QLCS TLVs.

ORAL SESSION II: SATURDAY, OCTOBER 1 | 11:15 AM –12:15AM

High-Resolution Climatology of the Afternoon-to-Evening Transition using Ground-Based Remote Sensing

Matthew Starke[1] and Kevin Knupp[1]
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The afternoon-to-evening transition (AET) is marked by an increase in the stability and shear of the planetary boundary layer (PBL) around the time of local sunset. Some time before sunset, the surface heat flux changes sign, allowing a surface-based stable layer to form. The growing stable layer becomes decoupled from the overlying mixed layer, which leads to a reduction in wind speed due to friction and the cessation of turbulent circulations that characterize the convective boundary layer. The increase in shear associated with the AET is important in tornadogenesis, especially in the southeastern United States, where many tornadic quasi-linear convective systems tend to occur in the evening. Most existing literature on the AET uses small-scale field campaigns, reanalysis data, or numerical modeling to describe the AET. The present study uses a 2.5-year dataset from the Mobile Atmospheric Profiling Network (MAPNet), including sodar and radar wind profilers, to construct a longer-term observational climatology of the AET with 5-minute temporal and 21-meter vertical resolution. In the present study, the dependence of the AET on the surface wind, cloud cover, and the time of year is emphasized. The impact of the AET is measured through its effects on wind and shear parameters. The tendency for the AET to generally be less significant with greater low-level cloud cover and greater surface wind speed is noted as consistent with prior literature. New results suggest that even a small amount of cloud cover can have a significant effect on the AET, that low wind speeds do not necessarily facilitate the AET, and that surface wind direction before sunset may be a predictor of the effects of the AET.

ORAL | POSTER

Simulating the Impacts of Pollen on Ice Cloud Formation

Yingxiao Zhang[1], Tamanna Subba[2], Brianna N. Hendrickson[3], Sarah D. Brooks[3], and Allison L. Steiner[4]

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[2]Brookhaven National Laboratory, Environmental and Climate Sciences Department
[3] Texas A&M University, Department of Atmospheric Sciences
[4] University of Michigan, Ann Arbor, Department of Climate and Space Sciences and Engineering

Primary biological aerosol particles (PBAPs) emitted from Earth's surface are linked to adverse health effects and have the potential to influence ice nucleation. Anemophilous (or wind-driven) pollen is one type of PBAP, and emitted pollen grains can rupture under high humidity to form smaller sub-pollen particles (SPP). Both pollen and SPP can be lifted to the upper troposphere under convective conditions, readily take up water and serve as cloud condensation nuclei (CCN) and ice nucleating particles (INPs), and therefore impact cloud formation and reflectivity. Although these biological aerosol have proven to be effective INPs in previous studies, they are typically not included in emission inventories and their impacts on cloud formation are understudied. Here, we include the emission and rupture of pollen in WRF-Chem simulations and investigate the impacts of pollen and SPP on both warm and ice clouds over the continental United States. We update the Morrison microphysics scheme inside WRF-Chem using aerosol-aware INP parameterizations, simulating ice nucleation from other aerosol (dust, soot, sulfate etc.) as controlled simulations. We incorporate ice nucleation from pollen and SPP in the model to evaluate pollen effects on ice cloud formation. The corresponding pollen and SPP INP parametrizations are obtained by laboratory experiments that indicate pollen grains are more efficient INPs than SPP and could contribute to ice cloud formation. We will discuss the impact of the addition of PBAP such as pollen on cloud microphysical processes, and highlight when and where pollen may be relevant in ice cloud formation.

ORAL | POSTER

Lighting the night: Application of VIIRS DNB for Monitoring Wildfire and Smoke Transport at Night

Meng Zhou[1], Jun Wang[2], Xi Chen[2], Lorena Castro Garcia[2], Xiaoguang Xu[3], David A. Peterson[4], Edward J. Hyer[4], Jeffrey S. Reid[4], Peter Richard Colarco[5,6], Steven D Miller[7], David Matthew Giles[5,6], Brent Holben[5,6], Zhuosen Wang[5,6], Arlindo da Silva[5,6], and Shobha Kondragunta[8]

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[2] *University of Iowa, Department of Chemical and Biochemical Engineering*
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Wildfire and biomass burning, and their associated smoke particles, play crucial roles in Earth's atmosphere, climate system, and human society. However, today's observations of smoke transport from space are mostly in daytime, while there is no operational satellite data to characterize the fire combustion efficiency in both day and night. Day-night band (DNB), as part of the Visible Infrared Imaging Radiometer Suit (VIIRS) sensor, provides the community the opportunities to explore the Earth at night in a quantitative way. Using the DNB in connection with other VIIRS bands, we developed a hybrid nighttime Fire Light Detection Algorithm 2 (FILDA-2) to achieve a comprehensive nighttime wildfire detection and parameterization of the combustion status of wildfire. We will show that with the aid of visible information at night, FILDA-2 is capable of detecting smaller and cooler fires at night and provide valuable information on the combustion efficiency of wildfire at the pixel level. Using the reflected moonlight received by the DNB, we also developed an algorithm for retrieving nighttime aerosol optical depth (AOD) for the rural areas during the western U.S. fire season. The retrieved AOD values show good agreements with spatiotemporally collocated AERONET and CALIOP AOD values, with linear correlation coefficient values of ~0.95 and ~86% of the AOD pairs falling in an uncertainty envelope of ± (0.085 + 0.10AOD). This is superior to AOD reanalysis from MERRA-2. A special case study will show that the nighttime AOD provides critical information for understanding the diurnal variation of smoke transport. These results affirm the significant potential of nighttime observation to improve the monitoring, analysis, and forecast of regional to global wildfire and biomass-burning aerosol distributions, filling a critical gap in the diurnal description of a critical element in Earth's climate system.

ORAL | POSTER

Evaluating the Impact of Soil Moisture on Agricultural Soil NOx Emissions and Air Quality

Daniel E. Huber[1], Eric A. Kort[1], and Allison L. Steiner[1]
[1] *University of Michigan, Ann Arbor, Department of Climate and Space Sciences and Engineering*

Soil emissions of nitrogen oxides (NOx) remain a highly uncertain process, due largely to our limited understanding of the environmental drivers that influence their emission, including soil moisture. Atmospheric chemistry studies often account for soil NOx with the Berkeley Dalhousie Soil NOx Parameterization (BDSNP), which estimates soil NOx emissions based on available soil nitrogen, soil temperature and soil moisture. This parameterization classifies each grid cell as either arid or non-arid, and applies one of two static relationships between soil NOx and soil moisture depending on that classification. However, many soil NOx emission studies have shown that this relationship can be more dynamic, with emissions exhibiting different regional relationships between soil moisture and soil NOx emissions. Here, we present an updated soil moisture function for the BDSNP that produces maximum soil NOx emissions at a wider range of values than the standard parameterization to better reflect the relationships observed both from flux chamber studies and regional satellite analyses. We implement the updated parameterization into the Weather Research and Forecasting model coupled with chemistry (WRF-Chem) to evaluate the influences of this parameterization change on emissions of NOx in intensive agricultural regions and the subsequent formation of secondary pollutants, with a focus on ozone. As NOx emissions associated with fossil fuel combustion decrease into the future, the relative contribution from these managed soils will increase. As such, improving our representation is key in understanding air quality in agricultural regions of the United States.

ORAL | POSTER

Impacts of Global Gasoline and Diesel Emissions on Ambient $PM_{2.5}$ and O_3 Pollution and the Related Human Health Burden for 2000-2015

Ying Xiong[1]
[1] *Wayne State University, Department of Civil and Environmental Engineering*

Global economic development and urbanization during the past two decades have driven the increases in demand of personal and commercial vehicle fleets, especially in developing countries, which has likely resulted in changes in year-to-year vehicle tailpipe emissions associated with aerosols and trace gasses. However, long-term trends of impacts of global gasoline and diesel emissions on air quality and human health are not clear. In this study, we employ the Community Earth System Model (CESM) in conjunction with the newly developed Community Emissions Data System (CEDS) as anthropogenic emission inventory to quantify the long-term trends of impacts of global gasoline and diesel emissions on ambient air quality and human health for the period of 2000-2015. Global gasoline and diesel emissions contributed to regional increases in annual mean surface PM2.5 (particulate matter with aerodynamic diameters 2.5 m) concentrations by up to 17.5 and 13.7 µg/m3, and surface ozone (O3) concentrations by up to 7.1 and 7.2 ppbv, respectively, for 2000-2015. However, we also found substantial declines of surface PM2.5 and O3 concentrations over Europe, the US, Canada, and China for the same period, which suggested the co-benefits of air quality and human health from improving gasoline and diesel fuel quality and tightening vehicle emissions standards. Globally, we estimate the mean annual total PM2.5- and O3-induced premature deaths are 139,700-170,700 for gasoline and 205,200-309,300 for diesel, with the corresponding years of life lost of 2.74-3.47 and 4.56-6.52 million years, respectively. Diesel and gasoline emissions create health-effect disparities between the developed and developing countries, which are likely to aggravate afterwards.

ORAL SESSION III: SATURDAY, OCTOBER 1 | 1:30 PM –2:30PM

A Genesis Potential Index for Polar Lows with Applications to Subseasonal to Seasonal Prediction

Kevin P. Boyd[1], Zhuo Wang[1], John Walsh[2], and Patrick Stoll[3]
[1] University of Illinois at Urbana-Champaign, Department of Atmospheric Sciences
[2] University of Alaska Fairbanks, International Arctic Research Center
[3] The Arctic University of Norway, Department of Mathematics and Statistics

Polar lows (PL) are intense maritime mesocyclones that typically develop during marine cold-air outbreaks events over the high-latitudes. The impacts posed by these systems to humans and the broader environment demand a robust understanding of the environmental factors that promote PL formation, and in turn, skillful prediction of PL activity. A PL genesis potential index is developed that relates the climatological spatial distribution of PL genesis frequency and key climate variables in a Poisson regression framework. It utilizes static stability and environmental baroclinicity as climate predictors and is able to skillfully capture the observed patterns of climatological PL activity, in addition to its interannual variability, across the sub-Arctic domain. We apply this framework to explore the subseasonal to seasonal (S2S) prediction of PL activity by utilizing reforecasts and real-time forecasts from the ECMWF extended-range and seasonal forecasting models to predict regional statistics of PL activity in a hybrid statistical-dynamical approach. Regional PL activity is skillfully predicted in all source regions at lead times of up to a month. Additionally, the predictability of PL activity is estimated using reanalysis data, and the effects of major climate modes on prediction skill are examined. We find that climate modes can strongly influence monthly prediction skill and are a potential source of predictability. Overall, our results highlight a promising prospect for S2S prediction of PL activity.

ORAL | POSTER

A Cloud Detection Neural Network to Detect Clouds using Airborne Cameras

Joseph Nied[1], Snorre Stamnes[1], Michael Jones[1], and Armin Sorooshian[2]
[1] *NASA Langley Research Center*
[2] *University of Arizona, Department of Chemical & Environmental Engineering*

We introduce a method that uses convolutional neural networks to detect the presence of clouds in airborne camera images. We train neural networks on human-labeled images extracted from airborne cameras on the P3 and King-Air aircraft under the CAMP2Ex and ACTIVATE NASA flight campaigns. The human-labeled data we supply to the network is a binary label and time stamp, indicating whether there is a cloud visible within the frame at the specified time stamp. The CDNN then trains and learns to identify clouds based on color, texture, patterns and visible characteristics by using the internal network structures of convolutions, pooling, and dropout layers. We quantify the performance of this Cloud Detection Neural Network (CDNN) by applying the model against human-labeled testing and observe where the model activates on the data and compare the classification to human labels to quantify performance. We report a 96\% accuracy in detecting clouds in Forward-viewing and Zenith-viewing testing datasets for their respective models. We further assess our performance by comparing the cloud masks of zenith and forward CDNN retrievals, with that of the prototype hyperspectral total-diffuse Sunshine Pyranometer (SPN-S) instrument's cloud optical depth data. Comparison of the CDNN with the SPN-S on time specific intervals resulted in 93% accuracy for the zenith-viewing CDNN and 84% for the forward-viewing CDNN. We present results from the CDNN based on airborne imagery from the NASA Aerosol Cloud Meteorology Interactions Over the Western Atlantic Experiment (ACTIVATE) and the Clouds, Aerosol and Monsoon Processes-Philippines Experiment (CAMP2Ex).

ORAL | POSTER

A Case Study of Midlatitude Noctilucent Clouds and its Relationship to the Secondary-Generation Gravity Waves Over Tropopause Inversion Layer

Haiyang Gao[1] (Presenter: Jiaxuan Miao[2])

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[2] *University of California, Los Angeles, Department of Atmospheric and Oceanic Sciences*

A sporadic case of noctilucent clouds (NLCs) was observed unexpectedly on the night of the 6–7 July 2020 in Beijing (40°2′N, 115°30′E). The noticeable wavy structures and observed ambient temperature (135.54K at the mesosphere and lower thermosphere [MLT]), both indicated that the increase in temperature oscillations could be the cold phase of gravity waves (GWs). The reasons for NLC formation were analyzed based on the observations and model data sets in our study. The real-time synoptic analysis revealed that there were GWs originally generated by a squall line in the troposphere. Due to the blocked effect of a stable tropopause inversion layer (TIL), the GWs broke, leading to strong energy dissipation near the TIL. The reverse ray tracing analysis between the TIL and NLCs' layer revealed the travel distance (206.88 km) and time (49.91 min) of GWs. These findings show that the turbulence over the TIL (at approximately 14.64 km) excited secondary GWs, which propagated upwards toward the mesosphere and probably interacted with diurnal and semi-diurnal tides. The cold phase of the larger-amplitude waves can provide optimal conditions for NLCs forming. Our study highlights the significance of dynamic coupling mechanisms regarding the effects from troposphere to MLT thermal conditions and offers a case study for the increasing occurrences of NLCs at midlatitudes.

ORAL | POSTER

The Impact of Subtropical Moisture within an Atmospheric River on Moisture Flux, Cloud Structure, and Precipitation over the Salmon River Mountains of Idaho using Moisture Tracers

Divya Rea[1], Robert M. Rauber[1], Huancui Hu[2], Sarah A. Tessendorf [3], Steve W. Nesbitt[1], Brian F. Jewett[1], and Troy J. Zaremba[1]

[1] *University of Illinois at Urbana-Champaign, Department of Atmospheric Sciences*

[2] *Pacific Northwest National Laboratory*

[3] *National Center for Atmospheric Research*

The impact of an atmospheric river (AR) on the flux of subtropical moisture across Idaho's Salmon River Mountains and precipitation over the mountains is evaluated using the Weather, Research, and Forecasting model with water vapor tracers (WRF-WVT). The AR impacted Idaho between 17-19 Jan 2017 during the Seeded and Natural Orographic Wintertime Clouds: The Idaho Experiment (SNOWIE) campaign. WRF-WVT is configured to isolate the subtropical moisture contribution to the AR, the moisture flux, and precipitation. Subtropical water vapor advected by the AR into Idaho is tagged and tracked in 3-dimensional space throughout the run. This allows the contribution of the subtropical moisture to the vertical distribution of water vapor and the precipitation to be directly calculated. The simulated cloud structure is compared with airborne radar data collected during two SNOWIE intensive operation periods.

This study found that more than 70% of the moisture flux and more than 80% of the precipitation across the Idaho mountains during SNOWIE IOP 4 could be attributed to subtropical moisture within the AR. Nearly all of the moisture flux in the upper cloud and 50% of the moisture in the lower cloud was attributable to the subtropical moisture. The subtropical moisture contribution within the AR to precipitation ranged from 35% in northern Idaho to more than 90% in southern Idaho. Across the entire period of impact of the AR, more than 60% of precipitation in Idaho was attributable to the subtropical moisture within the AR, with this percentage increasing towards the south across the state.

ORAL | POSTER

Orographic Modifications to Extreme Rainfall in a Mei-Yu Front

Ian Cornejo[1], Angela Rowe[1], Kristen Rasmussen[2], and Alison Nugent[3]
[1] *University of Wisconsin - Madison, Department of Atmospheric and Oceanic Sciences*
[2] *Colorado State University, Department of Atmospheric Science*
[3] *University of Hawai'i at Manoa, Department of Atmospheric Science*

Taiwan regularly receives extreme rainfall due to seasonal Mei-Yu fronts that is modified by Taiwan's steep and complex topography. For example, a Mei-Yu extreme rainfall case during June 2017 produced severe flooding and mudslides as a result of over 600 mm of rainfall in 12 hours near Taipei Basin and over 1500 mm of rainfall in 2 days near the Central Mountain Range (CMR). This 1-3 June 2017 case is simulated using the Weather Research and Forecasting (WRF) model with halved terrain as a sensitivity test. This study seeks to better understand the unique orographic mechanisms that increase extreme rainfall. The reduction in terrain height in WRF produced a decrease in rainfall duration and accumulation in Northern Taiwan and a decrease in rainfall duration, intensity, and accumulation over the CMR. The reductions in Northern Taiwan are partially due to a weaker orographic barrier jet due to lowered terrain height. With a weaker barrier jet, the front propagates south faster, decreasing the time rainfall accrues in Northern Taiwan. The reductions over the CMR are partially due to a lack of orographic enhancements to Mei-Yu frontogenesis near the terrain. A prominent feature missing with the reduced terrain is a redirection of post-frontal westerly winds back into the frontal convergence zone attributed to orographic deformation. These orographic features will be further explored using observations of heavy rainfall events captured during the recent Prediction of Rainfall Extremes Campaign in the Pacific 2022 field campaign in Taiwan.

POSTER SESSION: SATURDAY, OCTOBER 1 | 4:30 PM – 6:30PM

Application of Machine Learning in Air Quality Modeling for Bangladesh Considering the Effect Of COVID-19 Restrictions

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Although use of machine learning techniques in modeling air quality has gained popularity in recent times, very few models have accommodated the effect of COVID-19 like events. In terms of Air Quality Index (AQI), Bangladesh had the worst air pollution among 106 countries in 2020. Some studies have investigated the overall air quality change during the pandemic in Bangladesh. Previously, machine learning methods have been used in air pollution modeling of Bangladeshi cities. However, no studies have been done yet to model the air quality of Bangladesh including the effects of COVID-19. Main objectives of the project will be twofold- understanding the effect of COVID-19 lockdown on the air quality of Bangladesh and comparison and validation of two machine learning models for the prediction of Particulate Matter (PM) in Bangladesh considering COVID-19 like events. To fulfill the objectives, concentration of critical air pollutants will be first collected from Continuous Air Monitoring Station (CAMS) situated from 2012-2021. The air quality will be compared between 2019 and 2020 for each month. Later, Vanilla and Bi-directional Long Short Term Memory (LSTM) networks will be used to train a model for estimation of Particulate Matter ($PM_{2.5}$).

ORAL | POSTER

Investigating Stability of BVOC-Derived Secondary Organic Aerosol with Respect to Hydrolysis and Photolysis

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Atmospheric organic aerosols are either directly emitted from various anthropogenic and biogenic sources or converted from gas-phase organic species into secondary organic aerosols (SOA). SOA have substantial impacts on climate forcing, contributing either to global warming or global cooling depending on their physical and chemical properties. The extent of the impact of SOA on global warming or cooling is influenced by various atmospheric reactions which affect the chemical makeup of SOA in the atmosphere. For this study we look at the photolysis and hydrolysis of SOA. Photolysis and hydrolysis are chemical reactions with light and water, respectively, that break apart chemical bonds in molecules. We generated SOA from the ozonolysis of α-pinene and from the ozonolysis of limonene, which are both biogenic volatile organic compounds (BVOCs) with the same chemical formula but different chemical structures, and therefore undergo unique reactions. We performed photolysis and hydrolysis of both α-pinene-SOA and limonene-SOA at pH ~1, 3, and 5 to mimic different atmospheric environments. We monitored these reactions with mass spectrometry analysis and UV-Vis absorption measurements to see changes in composition and light-absorption of SOA. We conclude that both α-pinene SOA and limonene-SOA did not exhibit substantial changes in light-absorption during hydrolysis reactions, indicating an insignificant impact of water on the system. The speed of photolysis reactions of both α-pinene SOA and limonene-SOA were impacted by pH, with lower pH exhibiting a faster rate of reaction. These results help us to understand how photolysis and hydrolysis reactions affect the impact of SOA on climate forcing.

ORAL | POSTER

Improving UI-WRF-Chem simulation of surface aerosol diurnal variation in the United States through ground-based and satellite observations

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Atmospheric aerosols play an important role in Earth's environment, climate change, and public health. Atmospheric chemical transport models (CTMs), such as Unified Inputs (Initial and Boundary conditions) Weather Research and Forecasting model coupled with Chemistry (UI-WRF-Chem), can provide the forecast of aerosol distribution and surface air quality, and fill in the data gaps where and when satellite data is not available. However, UI-WRF-Chem still has deficiency and therefore yield significant discrepancy with respect to the observation data. This research seeks to improve the presentation of diurnal variation of aerosol mass concentration and aerosol optical properties (including size distribution) in United States in WRF-Chem through the integrated use of ground-based observations (AERONET, EPA and PurpleAir PM2.5) and satellite aerosol products (GOES-R AOD). Ground-based measurement of PM2.5 concentration is utilized to correct the emission inventory, thereby improving the simulation results of PM2.5 concentration by WRF-Chem. Therefore, this research adjusts the aerosol emission data of the WRF-Chem model utilizing EPA PM2.5 observation. Accurately modelling the particle size distribution and species of aerosols is important for aerosol optical information. Our work applied long-term AERONET and aerosol particle size distribution data to improve aerosol optical properties of WRF-Chem. After obtaining better simulation results, the GOES-R and TEMPO data are used to evaluate and constrain the model parameters and assess the model improvement in simulating hourly AOD and surface PM2.5. Preliminary result shows that the improved WRF-Chem model with adjusted emission data is in better agreement with diurnal variation curves of observation. The previous results also decrease WRF-Chem simulation errors of PM2.5 concentration in the United States, especially the urban areas of the east coast. Therefore, our work can improve the level of aerosol simulation in the United States.

ORAL | POSTER

Quantifying Impact of Organic Films on Cloud Condensation Nuclei Activity

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Surface-active organics are ubiquitous in atmospheric aerosol particles and can indirectly impact the Earth's climate by impacting cloud formation. Köhler theory describes the thermodynamic equilibrium that governs cloud droplet formation, dominated by two competing effects. The Kelvin effect and the Raoult's law state change of saturation vapor pressure due to the curved droplet surface and components of an ideal solution of liquids, respectively. Köhler theory has been confirmed for inorganic aerosols, but the situation becomes complicated for inorganic and organic mixtures. So far, the kappa-Köhler theory has been applied as an alternative in many models for well-mixed organic/inorganic components by calculating the hygroscopicity which based on volume-weighted average of each chemical species, but it does not consider the location of organics within the droplet. The existence of a hydrophobic organic-rich shell coating hygroscopic inorganic core will decrease both surface tension and water solubility. In this study, we present a method that incorporates an effective surface tension method for Kelvin effect and κ-Köhler theory for Raoult's law together into the stochastic particle-resolved PartMC-MOSAIC model to consider the influence of organic aerosol on cloud condensation nuclei activity. We will show sensitivity tests and calculate critical supersaturation and critical diameter for each different input variables representing different types of aerosols. The comparison of this modified method and previous results will help us to better quantify the contribution of organic films on cloud droplet formation and further influence on the Earth's climate.

ORAL | POSTER

Studying Air Quality in South Korea Using Chemical Transport Modeling and Satellite Data

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According to OECD, Korea was ranked first for exposure to PM2.5 fine particles among OECD countries in 2019. Air pollution in Korea is due to local emissions—from industrialized sources and high population density—and transboundary emissions due to prevailing westerlies from adjacent countries. PM2.5, which is a complex mixture of particles with different sizes and chemical compositions, is particularly known for adverse health effects. Also, NO2, emitted from vehicles, power plants, and industrial emissions, is also a very important air pollutant especially in populated areas. Filling in spatial and temporal gaps of air quality data is crucial and it can be done by combining ground and satellite-based measurements with air quality model outputs. In addition, sensitivity information from models can be applied to inverse modeling, data assimilation, source attribution and more. When attaining the sensitivity for specific output (receptor) with respect to all model inputs, the adjoint method is computationally efficient. This study is conducted to set a fundamental background to improve chemical transport modeling in South Korea by using multiple observation data. We used the mesoscale Weather Research and Forecasting (WRF) model to generate meteorological data and the Community Multiscale Air Quality (CMAQ) model for chemical transport modeling. Our first step is to use satellite and ground observation to evaluate CMAQ modeling simulation in March 2021, which provides a baseline for our future work. Our next step is to use the adjoint method for data assimilation to constrain emissions in South Korea at a finer temporal and spatial resolution using the Geostationary Environment Monitoring Spectrometer (GEMS) satellite data. In this work, we will compare model results and satellite products with ground observations.

ORAL | POSTER

Using Particle-resolved Aerosol Model Simulations to Determine the Hygroscopicity and Mixing State of Aerosols in Dynamic Chemical Reactors

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A common experimental set up used in laboratory studies of aerosols is the laminar flow mixing tube. In this study, we used the particle-resolved aerosol model PartMC to simulate the process of coagulation that particles undergo in such a flow mixing tube. Our goal was to determine which model better describes the experimental setup – the continuous stirred tank reactors (CSTR) or the plug flow reactor (PFR). During the experiment, the mixing evolution of ammonium sulfate and sucrose binary mixtures were observed along with the changes in their water uptake properties expressed as the single hygroscopicity parameter, κ. We used the measured size distribution information of the particles that were introduced into the tube to initialize the PartMC model simulation, and compared our simulation results to measurements of size distribution and CCN spectra after the aerosols traversed the tube and coagulated with each other. To determine the most suitable chemical reactor system for this setup, we compared the result from two simulations, one that assumed that the tube acts like a continuous stirred tank reactor (CSTR) and another that assumed that the tube acts like a plug flow reactor (PFR). For an ideal CSTR, the fluid is instantaneously and uniformly mixed upon entry resulting in a well-mixed reactor. Conversely in PFRs, the fluid is modeled as a series of infinitely thin coherent rings traveling in the axial direction each with distinct composition and perfect radial mixed in the radial mixing. For this study, the PFR setup resulted in a better agreement with the experimental data when comparing size distributions and CCN spectra, compared to the CSTR setup.

ORAL | POSTER

Improving the Ability of Air Quality Models to capture N_2O_5 Heterogeneous Chemistry

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Heterogeneous N_2O_5 chemistry is an important factor in air quality because of its influence on the production of ozone and particle nitrate. Air quality models are a useful tool for understanding this complex chemistry. However, current heterogeneous N_2O_5 parameterizations in air quality models do not accurately capture the chemical processes that influence N_2O_5 uptake and particle-phase reactions. We implemented a new N_2O_5 uptake parameterization and a new ClNO2 yield parameterization in the Community Multiscale Air Quality (CMAQ) model with the intention of improving model predictions of N2O5 chemistry. The CMAQ model was run from January 21 to March 16, 2015 to align with the WINTER 2015 flight campaign. The new uptake parameterization, based on the work of Gaston, et al. (2014), improved model predictions of N_2O_5 concentration compared to the existing Davis, et al. (2008) and Bertram & Thornton (2009) CMAQ parameterizations, but was limited by simplifications to the parameterization equations. The ClNO2 yield parameterization, based on the work of Staudt, et al. (2019), did not produce statistically significantly different ClNO2 concentrations compared to the model default. More work needs to be done to assess how each of these new parameterizations impact predictions of ozone and particle nitrate.

ORAL | POSTER

Characteristics of Interannual Variability in Space-based XCO_2 Global Observations

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Atmospheric carbon dioxide (CO_2) accounts for the largest radiative forcing among anthropogenic greenhouse gases. There is, therefore, a pressing need to understand the rate at which CO_2 accumulates in the atmosphere, including the interannual variations (IAV) in this rate. IAV in the CO_2 growth rate is a small signal relative to the long-term trend and the mean annual cycle of atmospheric CO_2, and IAV is tied to climatic variations that may provide insights into long-term carbon-climate feedbacks. Observations from the Orbiting Carbon Observatory-2 (OCO-2) mission offer a new opportunity to refine our understanding of atmospheric CO2 IAV since the satellite can measure over remote terrestrial regions and the open ocean where traditional in situ CO_2 monitoring is difficult. In this study, we analyze the IAV of column-averaged dry air CO_2 mole fraction (XCO_2) from OCO-2 between September 2014 to June 2021. The amplitude of IAV variations is up to 1.2 ppm over the continents and around 0.4 ppm over the open ocean. Across all latitudes, the OCO-2 detected XCO_2 IAV shows a clear relationship with ENSO-driven variations that originate in the tropics and are transported poleward. The XCO_2 IAV timeseries shows similar zonal patterns compared to ground-based in situ observations and with column observations from the Total Carbon Column Observing Network (TCCON). At lower degrees of aggregation (i.e., 5°x5° grid cells), there are larger inconsistencies with TCCON suggesting that one or both of the observing systems are affected by bias or systematic retrieval issues that are of a similar magnitude to the IAV signal. Our results suggest that OCO-2 IAV provides meaningful information about climate-driven variations in carbon fluxes and provides new opportunities to monitor climate-driven variations in CO_2 over open ocean and remote regions.

ORAL | POSTER

Overview of meteorology and chemistry of ozone episodes during the Lake Michigan Ozone Study 2017

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Spring and summertime ozone pollution remains a challenging air quality problem along the coast of Lake Michigan. Production of ozone over Lake Michigan combined with onshore daytime “lake breeze” airflow increases ozone concentrations preferentially at locations within a few kilometers of the shore. A collaborative field campaign (Lake Michigan Ozone Study 2017) took place during May and June 2017 to gather high spatio-temporal resolution data for refinement of conceptual thinking about these events, as well as evaluation and improvement of models. The campaign provided extensive observational datasets regarding ozone, its precursors, and the particulate matter and meteorology associated with ozone events through a combination of airborne, ship, mobile lab, and fixed ground-based sites.

An overview of the measurement platforms, meteorology, and air quality will be presented with a focus on sensitivities to emissions. The base case model had acceptable performance for daytime ozone overall (normalized mean bias of +1% domain-wide and -9% along the Lake Michigan coast), but underestimated peak concentrations, due to a combination of meteorological and chemical errors. Sensitivities are explored using the photochemical grid model WRF-Chem, including insights from tracking of individual reaction rates relevant to radical cycling and ozone production and the effects of perturbations of NOx and total anthropogenic VOCs. Multiple lines of evidence (modeled sensitivity, modeled formaldehyde/NOx ratio, independent box modeling) indicate hydrocarbon limited conditions in the southern portion of the lake during some episodes. Sensitivity of ozone to anthropogenic hydrocarbon emissions was smaller in the northern portion of the lake. Back trajectory analysis indicated differing source regions for both ground sites, Sheboygan and Zion, one explanation for the observed result. Independent box modeling at the Zion IL site supports increases in anthropogenic hydrocarbon emissions. Analysis of further sensitivities to anthropogenic and biogenic VOCs will also be discussed.

Pittsburgh and Air Pollution: A Study of Criteria Gases and Particulate Matter During the COVID-19 Lockdown

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The COVID-19 pandemic and early mitigation efforts of stay-at-home periods have offered a unique opportunity to study anthropogenic pollution. Poor air quality affects human health, and COVID-19 can exacerbate existing respiratory conditions. The Greater Pittsburgh Metropolis (Allegheny County, Pennsylvania) has experienced poor air quality throughout its history, and this makes Pittsburgh an ideal location to study pollution trends. Using ground-based Environmental Protection Agency AirData at four locations with varied socioeconomic statuses within Allegheny County, nitrogen dioxide (NO_2), sulfur dioxide (SO_2), ozone (O_3), and particulate matter with aerodynamic diameter less than 2.5 µm ($PM_{2.5}$) were observed for pre-, during, and post-COVID-19 trends. The datasets exhibit a reduction of pollutants during the COVID-19 period. Post-COVID levels rebounded to pre-COVID levels, theorizing anthropogenic pollution trends. These trends are consistent with NO_2 and SO_2 measurements from the space-based Tropospheric Monitoring Instrument (TROPOMI) data. Meteorological variants provided from AirData such as wind and temperature were analyzed and compared with the pollutant gases, however no conclusive relationship could be found with this data. This study can open the benefits of dual monitoring for pollution trends and COVID-19 while engaging possibilities on modifying human activities to reduce pollutants.

ORAL | POSTER

PyPartMC: a Pythonic Interface to a Particle-Resolved Monte-Carlo Aerosol Simulation Framework

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PyPartMC is a Python interface to PartMC, a particle-resolved Monte-Carlo aerosol model implemented in Fortran that simulates the microphysical processes that aerosol particles undergo during their lifecycles in the atmosphere, including new particle formation and emission from primary sources, Brownian coagulation, and removal by dry deposition and nucleation scavenging. PyPartMC allows users to leverage the resources of the PartMC simulation framework from a highly convenient and familiar Python environment without the use of shell or a netCDF Fortran library. The package is published on pypi.org and can be easily installed at the command line via `pip install PyPartMC` to grant the user access to the unmodified and versioned Fortran internals of the PartMC codebase on Linux, macOS, and Windows. PyPartMC is written in Fortran and C++, and the pybind11 framework is used to build the Python API, which is usable from other languages, such as Julia. PyPartMC also ships with a collection of Jupyter notebooks demonstrating how PyPartMC allows for streamlined usage of PartMC features in Python. A prerecorded demonstration using an example notebook will be shown in which PyPartMC is tested against PySDM, another package for simulating particle dynamics, facilitated by both packages being exposed in Python and ready-to-use in an easily shareable, web-based notebook with interactive output. Computational particles are assigned kappa values, passed by PyPartMC bindings to the Fortran internals, and used by PartMC to evaluate hygroscopic growth and equilibrium state under prescribed environmental conditions, such as relative humidity and temperature. This work is a step toward making research code more accessible to the wider community outside of modeling experts, including experimentalists and instructors in the classroom.

ORAL | POSTER

Learned Acceleration of 1-D Passive Scalar Advection for Atmospheric Modeling

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Numerical advection scheme is one of the core elements in earth system modeling including air quality model, and global climate model. Extensive research over the decades has resulted in accurate, and computationally tractable schemes. Machine learning is now gaining popularity to accelerate the scheme with fair outputs. In this presentation, we will introduce an approach of the learned solver to accelerate a numerical scheme. The training dataset was generated using Van Leer type scheme (L94) with a realistic wind field. We first generated a 10-day long 1-D wave in January 2019 using the GEOS-FP dataset. The modeling domain was the horizontal line passing through 39.0°N and bounded in North America. The spatial and temporal resolution of the original solver was 0.3125° and 5 min, respectively. We downsampled the output in both spatial (1×, 2×, 4×, 8×, and 16×) and temporal (1×, 2×, 4×, 8×, and 16×) resolutions and fed those into the neural networks. Our 3-layer convolutional neural network returned two coefficients for ($\Delta t/\Delta x$) and square of ($\Delta t/\Delta x$), respectively. Since we observed ReLU activation failed to represent the advection, we used GeLU and hypertangent function for neural net activation. We confirmed the learned schemes were accurate as the r2 was larger than 0.8 on any scale of coarsening. The ($16\Delta x$, $64\Delta t$) coarsening was ×15.8 faster than the original solver. We are currently working on adopting a scaling function for better generalization and this will be also presented.

ORAL | POSTER

Learning the Pattern Effect Using Model-Data Fusion: Observationally Constrained Green's Functions in a Hierarchical Bayesian Framework

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The "pattern effect"refers to the dependence of Earth's net radiative feedback not just on the global-mean temperature anomalies, but on the full pattern of surface temperature change. General Circulation Models (GCMs) show substantial uncertainty in the magnitude of this effect. This uncertainty is so large that a recent World Climate Research Program assessment concluded that the observational record of Earth's energy budget cannot constrain the upper bound of climate sensitivity. The lack of observational constraints on the pattern effect thus presents one of the largest roadblocks to improved estimates of climate sensitivity.

A primary difficulty lies in the fact that the joint satellite record of radiative imbalance and surface temperature is short (and correlated) relative to the number of degrees of freedom in the sensitivity map of top-of-atmosphere radiation to regional temperature changes – the so-called radiative Green's function. This leads to a classic under constrained problem.

Here we show how we can overcome this limitation and bring observational constraints on the pattern effect by assimilating GCM simulations and satellite data in a hierarchical Bayesian learning approach. We use GCMs' output to build a prior distribution for the spatial structure of the Green's function, a structure formally encoded as a Gaussian process. This prior distribution is then further constrained by using the CERES record of top-of-atmosphere radiation. The predictive skill of this approach is validated by using a perfect model approach, wherein we use prescribed-SST GCM simulations over the CERES interval as synthetic observations and evaluate the skill of the posterior Green's function in constraining the magnitude of the pattern effect in that model.

ORAL | POSTER

Evaluating the Skill of Linear Models of Salinity and δ18OSW Using Isotope-Enabled Climate Models

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Isotopic coral data serves as a proxy for tropical hydroclimate. In particular, the stable oxygen isotope in coral aragonite (δ18Oc) is related to both temperature and stable oxygen isotope presence in surrounding sea water (δ18OSW) at the time of calcification, the latter being strongly correlated with sea-surface salinity. This results in a simple linear model between δ18Oc, temperature, and salinity (S). This relationship makes δ18Oc a powerful proxy for inferring past variability in tropical climate. While the direct relationship between temperature and δ18Oc is often reduced to a constant coefficient, the relationship between S and δ18Oc varies in both space and time.

Here, we use data from the isotope-enabled simulations of the Community Earth System Model version 1 (iCESM1) to investigate the predictive skill of linear models relating δ18OSW and S across different time periods at several coral sites. iCESM1 data is split into two time periods: a training dataset of pseudo-observations mimicking the available data (2002-2005), and a validation dataset spanning the last millennium simulation (850-1850). iCESM1 output is then sampled at four coral sites, two of which were split into a dataset of temporal variations and one of spatial variations. We train linear regression models on the pseudo-observations, and evaluate the degree to which the resulting relation is able to hindcast the relationship between δ18OSW and S over the last millennium validation dataset.

Results revealed an overall strong predictive skill, particularly for the relationship fit to temporal variations. Relationships based on spatial variations have good predictive skill if the range of variations is large, but less predictive skill where the range of variations in the training dataset is small.

Finally, we implement a mixed effects (partial pooling) model to improve the ability to reconstruct past δ18OSW-salinity relations at sites with a limited range of present-day variations.

Change in the Frequency of Tornado Activity in China due to Climate Change

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Global climate change affects weather systems across all scales, but the uncertainty of this effect increases with decreasing scale. Tornadoes are examples of small-scale systems that can cause extreme damage, thus emphasizing the importance of estimating possible trends in their future occurrences. One way of doing so is to use output from global climate model (GCM) simulations to calculate environmental parameters, including the significant tornado parameter (STP), which can then serve as tornado-occurrence proxies. This is a form of statistical downscaling. Using seven models contributed to the Coupled Model Intercomparison Project phase 6 (CMIP6), we computed STP and other environmental parameters over the region of China for the historical time period 1970-1999 and for the future time period 2070-2099 under the Shared Socioeconomic Pathway (SSP) 585. Across most models, STP is higher in the future over the Northeastern, Southern, and Central and Eastern China. An average increase of 5-8 days per spring season, and 1-3 days per summer season of tornado-favorable conditions is projected for these regions in the future. The change in CAPE seems to be the most influential factor to the change in tornado-favorable environments during the spring, and the change in kinetic parameters gain more weight during the summer. We also find more inter-annual variability, or volatility, in the area of regions with tornado-favorable conditions in the future. This research will provide hazard assessments to inform future decision making.

ORAL | POSTER

Effects of Increasing Climate Variability on Human Health: A Case Study of Mosquitoes from Stormwater Infrastructure in Central Illinois

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Variability of climatic conditions can impact numerous important public health outcomes, including the prevalence of mosquito-borne diseases such as West Nile virus (WNV). 2002 and 2003 were epidemic years for WNV in the United States, with 685 cases of the novel virus reported from Chicago, IL alone. WNV's prevalence is most noted in urban areas due to juvenile mosquito habitats provided by subterranean stormwater drainage systems. Transmission in urban environments is favored by suitable weather conditions that stimulate and sustain mosquito reproduction and growth of vector species. Field and laboratory studies indicate that temperature is a crucial factor for suitable conditions for juvenile development, while precipitation plays a dual role: it can provide moisture necessary for aquatic habitats to persist, yet high rain rates lead to flushing of larvae out of subterranean stormwater habitats. The duration of these conditions, and locational features (i.e. topography, elevation and depth below ground), matter too.

This study addresses two significant questions: 1) What is the seasonality of suitable juvenile habitat conditions across different human land-use types that employ a mixture of subterranean and surface stormwater infrastructure, and 2) Whether the seasonality of these climatic conditions for mosquito reproduction have shifted over time, which in turn affects the timing and severity of mosquito-borne disease transmission. In our study, we consider over 20 years of multi-scale observations and fine resolution spatiotemporal reanalysis data during the 7-month warm season (April-November) for five small and midsize cities in north-central Illinois. We use weather station data from Illinois State Water Survey and NCEP/EMC 4 KM Gridded Stage IV Data to track the intersection of necessary temperature and precipitation thresholds known to support mosquito reproduction in subterranean and surface stormwater systems. Our analysis will thus identify when and where risk of WNV transmission is more prevalent across the urban-to-rural land-use gradient. Such results will be helpful in identifying the timing of mosquito-borne disease risk and inform policies to curb transmission.

ORAL | POSTER

The Impacts of Different Building Materials on Nearby Temperatures in the Summer Season in Raleigh, NC

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An array of nine HOBO temperature and relative humidity sensors were placed at locations within and nearby the North Carolina State University campus in Raleigh, NC to gather data during the months of June through September 2021. The goal of this study was to analyze the impact of different exterior building materials with different heat capacities on the summer season daily high and low temperatures in central North Carolina. The sensors were placed next to buildings with different exterior materials including brick, glass, concrete, and white aluminum composite panels. Additionally, a sensor was placed in a small, forested area on campus for comparison. Since the HOBO sensors did not record pressure, a nearby North Carolina State Climate Office ECONet mesonet sensor recorded the pressure data used to calculate wetbulb temperature. In this study, we examined the diurnal cycle of variables including wet bulb temperature, which is important for determining heat stress, as well as the temperature and relative humidity. In doing so, we found that different exterior materials can alter both the timing and magnitude of the daily high temperature and daily low temperature, with concrete and brick serving as the most influential building exteriors on their surrounding environments.

ORAL | POSTER

Impacts of Ecological Drought on Terrestrial, Aquatic, and Avian Species in Ohio

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Managing climate-related risks to water resources is a grand societal challenge, with uncertain, and potentially severe outcomes. This management can be more effective when there is a solid foundation of information and tools for identifying threats and evaluating their consequences, as well as potential actions to achieve resilience. The specific risk management challenge in the Ohio River Basin is planning for and managing hydroclimatic extremes. Drought is the costliest, most wide-spread, and longest duration of weather-related catastrophes. Drought has caused extensive ecological damage and reduced species populations throughout Ohio. For example, the 2012-2013 drought caused a 76.54% decrease in the red fox population and the Accipitridae family saw a 9.19% decline in population across Ohio. Here we examine the relationship between drought and 6 terrestrial mammals, 4 aquatic species, 118 breeding bird species, and 9 bird families. We evaluated the direct impacts of drought on these species and identified which drought indices are the most appropriate for evaluating ecological drought for each group of species. Our results quantify how major droughts in Ohio in 2002, 2007, 2012, and 2016 influenced species population. This study lays the foundation laid for providing guidance to ecological managers and decision makers to establish protections for ecosystems to reduce the impacts of ecological drought in Ohio.

ORAL | POSTER

Inventory of Federal Climate Engagement and Capacity-building Programs

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Engaging the public in climate action is vital to ensure that equitable climate actions are taken to combat the impacts of climate change. To ensure that the public is prepared for the scale of the climate crisis, the U.S. Federal government must support national initiatives to educate, train and engage citizens. Since the introduction of Executive Order 14008: Tackling the Climate Crisis at Home and Abroad in 2021, federal departments and agencies have been tasked with addressing climate solutions and justice, leading to an explosion of society-focused climate programs.
This session will present the results of the 2023 inventory of 513 U.S. federal climate education, training, communication, access to information, engagement, and coordination programs across 12 federal departments and 9 agencies, covering both existing and proposed programs in the 2023 budget. The inventory covers all aspects of climate work, from K-12 education to applied science, workforce development to Tribal adaptation. Additionally, the inventory includes programs funded through the Build Back America bipartisan infrastructure budget. The foundation laid by this research will encourage coordination of resources, knowledge, and best practices amongst the Biden administration, federal agencies, and non-federal partners. This ecosystem of federal action-focused climate policy will ensure that society is receiving necessary resources to take action and build a climate ready nation.

ORAL | POSTER

Generating High Resolution Daily Soil Moisture by Applying Machine and Deep Learning

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Soil moisture is one of the important climate variables and it plays a great role in global climate because it is one of the significant components in the hydrological cycle for weather conditions. Moreover, it helps to better understand, estimate, and predict the drought, and the flooding. Soil moisture influences crop yield, and irrigation planning. Given that importance, it is essential to study the availability and sources of the soil moisture datasets. Soil moisture datasets can be found from many sources such as in-situ, model-derived, and satellite-derived. However, every data source has some limitations and more specifically these products have a coarse spatial resolution. The purpose of this study is to generate higher resolution of soil moisture products by implementing artificial intelligence (AI) techniques. Here we will apply machine learning (ML) methods and deep learning (DL) methods to generate field-scale soil moisture estimates. These methods will be evaluated by calculating the accuracy measures such as correlation coefficient (R), goodness of fit (R2), root mean square error (RMSE), unbiased RMSE, unbiased root mean square deviation (ubRMSD).

Alterations in Land-Ocean Parameters by Considering Atmospheric Meteorology Associated with Tropical Cyclone "Tauktae"

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India has a dynamic climate system along with a long coastline from the east (Bay of Bengal) to the west (Gujarat). Due to its more extensive coastline, it is prone to natural calamities as its dynamic in nature. Cyclones are usually affected during pre and post-monsoon seasons. This period is sensitive for India due to its variability in climatic conditions. Recently the frequency of tropical cyclones has increased in the Arabian Sea. Tropical cyclone “Tauktae” hit the western coastline of India on 14th May 2021 with WS of 65 km/h at 998 mb pressure, and Cyclone ended on 19th May 2021 with 65 km/h WS at 996 mb pressure. The landfall occurred on 17 May 2021 with a peak point of WS 220 km/h at 935 mb pressure. It causes devastating damage to the western, northern, and central parts of India. The country already suffering from the second wave of novel COVID-19, the day of landfall has been recorded as the most tremendous loss of lives in Gujarat due to synergized effect of COVID-19 and cyclone. A detailed analysis of satellite sensor-based data, Bio-Argo data, and ground data has been done to understand the alteration in land-ocean, atmospheric and meteorological parameters prior to and after the formation of the “Tauktae” cyclone. This study considered the changes in atmospheric parameters such as air temperatures (AT) over land and ocean for two years (2020 and 2021) for the same period, TCO and COVMR at four different boxes, PM2.5 (Gandhinagar, Gujarat), and ocean parameters as sea surface temperature (SST) anomalies, vertical profiles of temperature and salinity near to track. Meteorology in form of RH, H2O MMR, and Omega at different pressure levels (100-1000 hPa), vertical format with wind speed and direction. All these parameters show the relationship between each other prior, during, and after the cyclone.

ORAL | POSTER

Python Development for Unstructured Mesh Analysis & Visualization

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The current Scientific Python Ecosystem (SPE) has had decades of support and contribution for regular structured grids. However, the same is not the case for unstructured data and meshes. This lack of maturity means that typical data science routines such as analysis and visualization often prove to be challenging.

Project Raijin is an NSF EarthCube funded project aimed at solving these issues. For Visualization, we can represent our unstructured meshes as polygon meshes. This allows for us to visualize our meshes without the need for expensive interpolation algorithms. This also simplifies the overall visualization workflow. For Analysis, development of the UXarray Python packages allows for users to easily work with unstructured data. It supports many analysis and data loading functions that directly operate on unstructured data.

Here we showcase the efforts to provide and develop these tools. Specifically, additions to the UXarray package and visualization research are discussed. Development began as part of the SIParCS program and continued throughout the academic year.

ORAL | POSTER

Multiscale Characteristics within Tropical Easterly Waves that are Crucial for Tropical Cyclogenesis over the Atlantic

Kenneth Leppert II[1], and Connor DeLaune[1]
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Tropical cyclones can have major implications on people's lives and property, yet a complete understanding of tropical cyclogenesis and intensification remains elusive. Over the Atlantic, tropical easterly waves (TEWs) serve as crucial precursor disturbances in tropical cyclogenesis. This research has two goals: determine what conditions across which scales best distinguish easterly waves that develop tropical cyclones (i.e., developing waves [DWs]) from those that do not (i.e., non-developing waves [NDWs]), and determine how larger-scale conditions impact the smaller scales relevant to tropical cyclogenesis.

Wave troughs were identified subjectively by locating relative maxima in total precipitable water (TPW) using the Cooperative Institute for Meteorological Satellite Studies (CIMSS) Morphed Integrated Microwave Imagery at CIMSS TPW product between the coast of Africa (i.e.,15°W) to 100°W and from 5°N to 20°N for July–October for 2008–2018. These wave troughs were then separated into DWs and NDWs using the National Hurricane Center's Tropical Cyclone Reports. Eulerian and Lagrangian composites of various mesoscale and convective-scale variables (e.g., vorticity, wind shear, fractional coverage of IR brightness temperatures <240 K, etc.) were created using NASA's Modern-Era Retrospective analysis for Research and Applications Version 2 (MERRA-2), NOAA GridSat-B1, NASA Tropical Rainfall Measurement Mission, and NASA Global Precipitation Measurement Mission datasets.

Results from the Eulerian analysis suggest that on the mesoscale (i.e., across only the wave troughs), DWs are generally associated with conditions more favorable for tropical cyclogenesis (e.g., greater low-level vorticity, greater upper-level divergence, etc.) relative to NDWs. The Lagrangian results support these findings with DWs being associated with a steady increase in low-level vorticity, deep-layer moisture, and coverage of IR brightness temperatures (BTs) less than 240 and 210 K leading up to and after development. It appears that the dynamical variables and IR BTs provide the best distinction between DWs and NDWs from the Eulerian and Lagrangian perspectives.

ORAL | POSTER

Preliminary Analysis of the 1800 UTC 01 February- 0000 UTC 06 February Frontal System Sampled Twice by IMPACTS

Lauren Beard[1], Troy Zaremba[1], and Rober M. Rauber[1]
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Between 1 Feb 2022 18 UTC and 6 Feb 2022 00 UTC, a very slow-moving cold front moved across the Midwestern and Eastern United States producing snowfall accumulations of 6-12 inches or greater across a wide swath extending from Oklahoma to Maine. The cold front was associated with a stream of moisture flowing from SW to NE ahead of, and over the front, as seen in the high values of integrated water vapor content present at the time of the NASA IMPACTS research flights of the NASA P-3 and ER-2. IMPACTS sampled the snowstorm associated with the cold front twice with both the P-3 and the ER-2. In the first flight over the Midwest, the ER2 flew 2 flight legs, one northbound and one southbound, then returned to base, while the P-3 flew 7 flight legs at 5 altitudes, all above the melting level as seen in the radar data. In the second flight, the P3 and ER2 flew a lawnmower pattern across the NE U.S., the P-3 sampling 6 altitudes in eight flight legs. In this poster, I present a synoptic and radar analysis of this storm and relate the frontal structure to mesoscale flow characteristics.

ORAL | POSTER

Synoptic Analysis of Two 14-Day Extreme Precipitation Events in the Northwestern United States

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[2] University of Oklahoma, School of Metorology

Stakeholders would benefit from knowing more in advance when extreme weather events will happen. Therefore, information on a sub-seasonal to seasonal timescale will be needed, but the skill is very low, and research is needed to improve it. Research has already been done for broad regional information of 14-day extreme precipitation events. This study looked at two case studies of extreme precipitation events out of the northwestern region, one in 2015 and the other in 2018. ERA5 data, PRISM, and Wyoming soundings, was used to find synoptic drivers that caused the two events to occur. It was found that the 2015 event in the West Coast region happened due to the position of the trough over the Pacific Ocean, creating an atmospheric river. For the 2018 event in the Mountain West region, the ridge was the main cause of the event, as it assisted in bringing a supply of moisture in from the Pacific Ocean. In both cases, the jetstream played a role in determining if an area will get a lot of moisture to create the extreme events. Both of these events also had the same supplier for moisture, the Pacific Ocean. It was also found that these events were not just one system precipitating for over 14 days, but rather from three different systems. This study will be useful for stakeholders, who can use the information from these case studies to better mitigate risk from future events.

ORAL | POSTER

Examining the Effects of Shear-Generated Turbulence within Kelvin-Helmholtz Waves in Mountainous Terrain on Microphysical Processes using Radar Range Height Indicator Scans

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Kelvin-Helmholtz (KH) waves have been shown to lead to the modification of microphysical processes within complex terrain during the Olympic Mountains Experiment (OLYMPEX). While these waves often form upstream of orography and tend to form in regions of shear-related turbulence (Bulk Richardson Number <0.25), the mesoscale mechanisms for their formation remain unexplored. This study documents the evolving characteristics of KH waves observed during the 17 December 2015 OLYMPEX field campaign intensive observing period (IOP) within the Olympic Mountains using range height indicator (RHI) scans from the NASA S-band Polarimetric (NPOL) and Doppler on Wheels (DOW) radars.

Previous studies have shown that KH waves, forming above, within, and below the boundary layer, modify microphysical processes in the presence of vertical windshear and statically stable environmental conditions. The kinematic characteristics, including vertical windshear, respective to vectorial and velocity changes, were quantified up-valley of their location using the DOW radar located within the Quinault Valley to understand KH wave formation and maintenance and resulting modification of microphysical processes. Low-level wind velocity in opposing directions, correlating with altitudes from surface level to ~7.6 km, oscillated throughout KH wave formation. Calculation of the buoyancy term in relation to the flow shear term revealed high quantitative values of atmospheric turbulence in the timeframe of KH waves formation. From analysis of the radar data, it was found that atmospheric turbulence was present in strong vertical wind shear, and that KH waves formed west of the DOW location, in the foothills of the Olympic Mountains. Future work will examine radar-determined atmospheric flow instability throughout varying times within the DOW data during KH wave formation and evolution.

ORAL | POSTER

A Spatial Analysis of Ohio CoCoRaHS Stations

Joseph W. Forbeck[1], and David A. Call[1]

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Having a tight web of meteorological observations is very important in the field of meteorology. This is especially true for precipitation, as it is much more variable spatially when compared to other variables. Therefore, precipitation is not well captured by networks such as ASOS, which are relatively sparse. The Community Collaborative Rain, Hail, and Snow Network (CoCoRaHS) was created in 1998 specifically to rectify this issue. There are now many volunteer-run CoCoRaHS stations throughout the country, but are there enough? Are there spatial gaps that leave regions unaccounted for? Understanding the distribution of CoCoRaHS stations is key to identifying regions where the network could be further strengthened.

Ohio was chosen for this study because of its unique variety of landscape and culture. Using GIS, we discovered that there are many clusters of CoCoRaHS stations throughout Ohio, leaving many gaps, especially in the southeastern portion of the state. Participation rates show an even more interesting pattern. To examine this, Ohio was broken up into three "regions:" urban, deciduous forest, and row cropland. There are clear participation differences among these three regions. Urban areas had by far the lowest CoCoRaHS participation rates, while row cropland regions had the highest. The forested areas of eastern Ohio had participation rates somewhere in the middle. When coupled with lower population totals, the forested region of eastern Ohio has the weakest web of stations. This region should be targeted the most by CoCoRaHS for recruitment.

ORAL | POSTER

Regional Feature of Storm Tracks' 20-30 day Periodicity in Austral Summer

Zhaoyu Liu[1], and Lei Wang[1]

[1] *Purdue University, Department of Earth, Atmospheric and Planetary Sciences*

The Southern Hemispheric (SH) storm tracks exhibit a robust intraseasonal periodicity of 20-30 days, representing a regular pulsing of zonal-mean extratropical eddy activity. Such periodic behavior has important implications for understanding and predicting the weather and climate system. Conventionally, this periodic behavior is defined by the leading EOF pattern of the zonal-mean eddy kinetic energy (EKE) and referred to as Baroclinic Annular Mode (BAM). However, while the leading mode of zonal-mean EKE captures the storm track variability, it remains debated about the fundamental dynamics for the 20-30 day periodic behavior. This calls for a process-level investigation of the regional behavior of SH storm track, which would serve as building blocks for a deeper understanding of BAM.

In this paper, we study the regional features of SH storm tracks by decomposing the variability of local wave activity into synoptic (2-7 days) and intraseasonal (10-45 days) components following the approach by Blackmon et al 1977. While the synoptic variability of LWA is mainly featured by a zonally symmetric structure, we identify a robust localization of the intraseasonal variability, including the 20-30 day periodicity, over the south Pacific. Is this strong localized feature suggesting that BAM is induced by the strong regional SST front over the Indian Ocean? To test this hypothesis, we perform fixed-SST experiments using CAM to evaluate the influence of localization of SST patterns on the resulting regional features of the BAM. However, even entirely removing any localization of SST over midlatitude regions fails to weaken the intraseasonal variability pattern. Conversely, removing localization of tropical SST can reduce the intraseasonal variability by more than a half. We will show key circulation patterns among the experiments to investigate an alternate hypothesis whereby the zonally asymmetry of climatological basic state induces a localization of 20-30 day periodic variability.

ORAL | POSTER

Could the Nonlinear Schrödinger Equation be a canonical evolution equation governing atmospheric blocking?

Ka Ying Ho[1], and Lei Wang[1]
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Atmospheric blocking (the stagnation of the weather systems) often causes weather extremes in the mid- to high-latitudes, yet its first-order dynamics are still not well understood. While synoptic weather systems typically last 3-5 days, atmospheric blocking can last 10-20 days. Despite rich literature, atmospheric blocking's first-order dynamics remain enigmatic.
Inspired by growing evidence of the propagating Rossby wave packets as a critical aspect in block life cycles, it becomes natural to connect such observations with the solution of a particular type of nonlinear equation - the Nonlinear Schrödinger (NLS) Equation. We assess a key and classical hypothesis that views atmospheric blocking as governed by the NLS Equation, which was first proposed by Benney (1979) and Yamagata (1980). To fill the gap between the well-documented theory-driven approach and the rising data-driven approach, we will demonstrate numerical solutions of the NLS equation in a wide range of flow regimes and compare against the observed wave pattern evolution of atmospheric blocking. In the next step, we will assess the solutions of the NLS equation against blocking flow patterns in idealized models and in observations.

ORAL | POSTER

Preliminary Categorization of 2020 and 2022 IMPACTS Cyclones for the Analysis of Wintertime Cyclones from a Satellite Perspective

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This work categorizes the 2020 and 2022 IMPACTS cyclones using visible and brightness temperature images from MODIS on Terra and Aqua along with surface, 850 mb, and 300 mb ERA5 reanalysis data. IMPACTS sampled Miller type A cyclones, Miller type B cyclones, Alberta clippers, Great Plains cyclones, extended cold fronts, and a Gulf Coast cyclone. This method of categorization will be used to identify wintertime cyclones from November 1st to March 1st over the period with satellite data and ending at the final year of the IMPACTS field campaign (2002-2023). The resulting database will be used to statistically compare satellite data on wintertime cyclones for the past ~20 years to similar data gathered during IMPACTS 2020, 2022, and eventually 2023. The IMPACTS dataset is relatively small compared to the number of wintertime cyclones that have impacted the US over the past ~20 years. There is a potential that data from IMPACTS is biased from only sampling a small percentage of storms, for a limited time, and along narrow flight tracks. Satellite data such as cloud top temperature, pressure, phase, and height from MODIS, cloud top heights and cloud track wind from MISR, Ku and Ka band radar from GPM, lidar from CALIPSO, and w band radar from CloudSat provides a strong dataset over multiple years of wintertime cyclones. Comparing IMPACTS data to these data from satellites will help determine how closely the data from IMPACTS represents wintertime cyclones.

Diagnosis of Arctic Cyclone Structure and Comparison with Midlatitude Cyclones

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Using the ERA5 reanalysis and an Arctic cyclone (AC) track dataset with more than 10,000AC tracks, we examined the similarities and differences between Arctic cyclones and midlatitude cyclones, regarding how the cyclone characteristics change as they propagate into the Arctic, and how Arctic cyclones developing in the Arctic differ from those originating from the midlatitudes. Three groups of cyclones are examined, i) Arctic cyclones forming in the polar region (≥70N); ii) Arctic cyclones originating from the midlatitudes (<70N); and iii) midlatitude cyclones that later propagate into the Arctic. More ACs form in the polar region than in midlatitudes in all seasons. Regarding seasonality, ACs of the polar origin occur most frequently in boreal fall and winter, mainly due to frequent cyclogenesis over the Nordic Seas. ACs of the midlatitude origin occur most frequently in boreal summer. As cyclones propagate from midlatitudes into the Arctic, their vertical tilt is reduced, and they become more symmetric. Arctic cyclones are, on average, weaker than midlatitude cyclones and undergo strong intensification less frequently. In addition, ACs of the midlatitude origin are generally weaker than those of the polar origin. Positive potential vorticity anomalies extend into the stratosphere for ACs of the midlatitude origin and of the polar origin, although the former are associated with weaker stratospheric PV anomalies than the latter. ACs are characterized by a warm-core structure in the lower stratosphere, consistent with previous studies. However, the warm-core structure cannot be fully explained by adiabatic warming as suggested by previous studies. Instead, it is found that diabatic processes play an important role.

ORAL | POSTER

Analysis of Energy Regime Transitions above the Southern Ocean

Branson Starr[1], Tiffany Shaw[1], Osamu Miyawaki[1], and Malte Jansen[1]
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In the modern climate, convective and advective heating are both important for balancing radiative cooling (so called Radiative Convective Advective Equilibrium, or RCAE) in the atmosphere above the Southern Ocean (60S - 70S). In response to an increase in CO2, the atmosphere above the Southern Ocean undergoes a transition to a radiative advective equilibrium (or RAE) regime, which today is only found in the polar regions. Here we use a moist static energy framework to show that the regime transition is predominantly associated with a decrease in convective heating (surface turbulent fluxes) and is not due to significant changes in radiative cooling. Diagnosing the surface energy budget further reveals that the decrease in surface turbulent fluxes is balanced by the divergence of energy flux in the ocean mixed layer, likely due to passive upwelling of cold waters from below. In order to further test the importance of ocean energy flux divergence for the regime transition, we vary the ocean energy flux in an idealized column model. Our results demonstrate the transient ocean response to increased CO2 has an important impact on the atmospheric energy balance regime over the Southern Ocean.

ORAL | POSTER

Observations of the Macrophysical Properties of Cumulus Cloud Fields over the Tropical Western Pacific

Michie Vianca De Vera[1], Larry Di Girolamo[1], and Guangyu Zhao[1]
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Small cumulus cloud fields play a very important role in the global water and energy cycles. However, they can be difficult to quantify using meteorological satellite datasets and lead to large uncertainties in their representation in climate models. Using high-resolution satellite data and data from field campaigns remains our primary method for accurately retrieving the properties of these small clouds. In this study, the macrophysical properties of cumulus cloud fields over the tropical western Pacific are examined using satellite and aircraft data collected during the Cloud, Aerosol and Monsoon Processes Philippines Experiment (CAMP2Ex) mission from August to October 2019. We summarize the observed macrophysical properties of the cumuli, including the size, shape, and spatial (horizontal and vertical) distributions, based on high resolution Terra-ASTER data that was tasked for CAMP2Ex. We demonstrate the improvements to the MISR-resolution-corrected cloud fraction product when its training set is expanded to include the CAMP2Ex ASTER dataset. Finally, we compare our results and environmental conditions to those obtained over the tropical western Atlantic as part of the Rain In Cumulus over the Ocean (RICO) experiment.

ORAL | POSTER

Retrieving 3D Volumetric Properties of Clouds from Multi-Angle Imagery

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Our global understanding of clouds and aerosols relies on the remote sensing of their optical, microphysical, and macrophysical properties using, in part, scattered solar radiation. Current operational remote sensing retrievals of this sort utilize strong assumptions which compromise retrieval accuracy of clouds and their adjacent aerosol when clouds form highly heterogeneous structures such as in the fields of climatically important trade cumulus. To address this limitation, we introduce and validate an algorithm for retrieving the 3D volumetric properties of atmospheric constituents using multi-angle, multi-pixel radiances and a 3D radiative transfer model. The retrieval, which is implemented in publicly available software, utilizes an iterative, local optimization technique to solve a generalized least-squares problem and thereby find a best-fitting atmospheric state. In doing so, it eliminates the biases in remote sensing due to the use of 1D radiative transfer but instead introduces errors due to the limited information content of the measurements.

ORAL | POSTER

Satellite-observed Changes of Surface Reflectance, Emissivity, and Temperature due to Solar Farming and the Implication for Radiation Budget

Chongxing Fan[1] and Xianglei Huang[1]

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Solar farms consist of arrays of solar panels to convert solar energy to electricity. Building solar farms has become an acknowledged approach to mitigate global climate change. Meanwhile, solar farm deployments can impact the local surface radiation budget and climate by changing the surface radiative properties. So far, modeling studies have primarily focused on simulating the impact caused by surface albedo changes due to solar farm deployments. Such modeling studies lack long-term observational constraints and ignore the longwave radiative effect of solar farms.

In this study, we used Moderate Resolution Imaging Spectroradiometers (MODIS) aboard the NASA Aqua satellite to quantify the change of surface shortwave spectral reflectance, longwave spectral emissivity, and skin temperature from six solar farms in the southwestern U.S. Our case study suggests a 20-25% reduction of surface reflectance over the seven MODIS shortwave bands due to the solar panel installation. Such a reduction in surface spectral reflectance leads to a ~23% decrease in the surface upward shortwave broadband flux and a ~14-18% decrease in the clear-sky reflected shortwave flux at the top of the atmosphere. Five out of the six solar farms show unambiguously detectable decreases in surface spectral reflectance. Meanwhile, although current surface retrieval algorithms have large uncertainty and disagreement in detecting surface longwave emissivity and temperature changes over solar farms, they agree that the outgoing longwave radiances over the MODIS infrared window channels are reduced.

Globally if all the bright deserts were covered with solar panels similar to what has been studied here, the estimated instantaneous TOA shortwave radiative forcing would be 0.5 W m-2, and the longwave radiative forcing would be at least one magnitude smaller than the shortwave one (< 0.05 W m-2). Nevertheless, its local impact is considerable and could propagate to affect the local boundary layer and even regional climate pattern.

ORAL | POSTER

On the Radar Detection of Cloud Seeding Effects in Wintertime Orographic Cloud Systems

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Recent studies from the Seeded and Natural Orographic Wintertime Clouds: the Idaho Experiment (SNOWIE) demonstrated definitive radar evidence of seeding signatures in winter orographic clouds during three intensive operation periods (IOPs) where background signal from natural precipitation was weak and a radar signal attributable to seeding could be identified as traceable seeding lines. Except for the three IOPs where seeding was detected, background natural snowfall was present during seeding operations and no clear seeding signatures were detected. This paper provides a quantitative analysis to assess if orographic cloud seeding effects are detectable using radar remote sensing when natural background precipitation is present. We show that a 5-10 dBZe change in Ze is required to stand out against background natural Ze variability. In order to have an increase in Ze that is distinguishable from the background, the seeding effect must typically be large ($\gtrsim$ 5%) and background IWC must be minimal. At best, a minimum of an 82% reduction in the IWC from a size distribution with heavy background precipitation from SNOWIE is required to distinguish a seeding signature at W-band, and then only if the IWC is increased by 15% of the original size distribution background as a result of seeding. This analysis implies that seeding effects will be undetectable using radar remote sensing within natural background snowfall unless the background natural IWC is minimal, and the seeding effects are large. In other words, the absence of a radar seeding signature in a cloud with background reflectivity cannot be used to as evidence that a seeding effect did not occur.

ORAL | POSTER

The Prediction of Potential Tornado Intensity Using Machine Learning

Michael Sessa[1] and Robert J. Trapp[1]
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Trapp et al. (2017, 2018; JAS) used theory and idealized numerical simulations to develop the simple hypothesis that wide, intense tornadoes should form more readily out of wide, rotating updrafts. Sessa and Trapp (2020; WAF) manually analyzed radar data on 102 tornadic mesocyclones to test this hypothesis. Their analysis focused explicitly on the pre-tornadic mesocyclone width and differential velocity: this allowed for the elimination of the effects of the tornado itself on the mesocyclone characteristics. Herein, we use an expanded dataset (300 tornadic mesocyclones) to determine the generality of their results and explore relationships between the near-storm environment and tornado intensity. Consistent with Sessa and Trapp (2020; WAF), the linear regression between the mean, pre-tornadic mesocyclone width and the EF rating of the corresponding tornado yields a coefficient of determination (R^2) value of 0.69. This linear relationship is higher for discrete (supercell) cases (R^2=0.77), and lower for QLCS cases (R^2=0.47). Overall, we have found that pre-tornadic mesocyclone width tends to be a persistent, relatively time-invariant characteristic that is a good predictor of potential tornado intensity, conditioned upon tornadogenesis. These findings have motivated us to explore tornado-intensity prediction approaches using pre-tornadic mesocyclone characteristics and other data such as the near storm environment through machine learning applications. Several classification machine learning algorithms were implemented and used to examine their skill in predicting significant or non-significant tornado intensity for a given storm. Logistic Regression, Random Forests, and Gradient Boosted Decision Trees were found to be the most skilled classifiers as measured by several cross-validated binary classification metrics as well as performance diagrams such as precision-recall and receiver operating characteristic curves. Adequacy of training, model reliability, and the significance of results was also explored. Tuning of hyperparameters through different search methods was also completed to optimize the performance of the models. Finally, feature importance and the decision-making process within each model was explored to help reveal a more physical understanding of the model performance and results, as well as relationships between the predictors and tornado intensity including the establishment of critical thresholds of predictors. The pre-tornadic radar predictors of mesocyclone width and differential velocity were the most important followed by environmental vertical wind shear and composite environmental parameters. Our results demonstrate a skilled binary prediction of tornado intensity, conditioned upon tornadogenesis, and the potential for these machine learning applications to become a helpful resource in an operational setting.

Increased Tornado Activity in Illinois During Severe Weather Off-season

Alexander Duffus[1]
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Many people believe that tornadic activity is very unlikely during what is considered the off-season (Nov-Feb) for severe weather in the midwestern United States. However, in recent years, the Midwest has experienced severe weather set-ups in the off-season that have produced more tornadoes. The purpose of this project was to identify if off-season tornadic activity in Illinois has increased over the past 30 years. The answer to this question is important to further communicate this new trend and inform the public to be weather aware during all times of year. Data was collected for confirmed tornadoes from the years 1990-2022 in Illinois from The Storm Prediction Center. The Oceanic Nino Index values were calculated by averaging the NDJ and DFJ three-month averages reported by the National Oceanic Atmospheric Administration for each given year. This index was calculated to see if there was a correlation between a La Nina pattern and increased tornadic activity in the off-season.

During the inquiry, it was evident that the number of tornadoes reported during the off-season in Illinois has increased. Over the last 12 Off-Seasons (2010-2022), 8 of them have been over the 30-year average. Many of the above-average seasons had tornado outbreaks. The data show a sharp increase in reported tornadoes after the 2010-2011 season. There is a correlation between heightened tornadic activity in the off-season with a weak La Nina pattern.

ORAL | POSTER

Understanding the Impact of the Lower Stratospheric Thermodynamic Environment on Observed Overshooting Top Characteristics

Melinda T. Berman[1], Robert J. Trapp[1], Stephen W. Nesbitt[1], Larry Di Girolamo[1], Yulan Hong[1], and Edward C. Wolff IV[1]

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Overshooting tops (OTs) extend from deep convective updrafts above the stable layer at the tropopause into the stratosphere. They can result in irreversible transport of aerosols, smoke, water vapor and other mass from the troposphere into the stratosphere. This transport can impact both the chemical composition of the stratosphere and induce dynamic perturbations. Recent work has examined OT characteristics such as area and how this relates to midlevel updraft structure. Other studies have shown how static stability in the lowermost stratosphere impacts other observed features at storm top. A knowledge gap remains, however, in understanding how stability in the lowermost stratosphere (LMS) specifically impacts OT characteristics including area, depth and injection duration. These relationships may be useful in describing mid- and low-level storm dynamics from satellite-observed characteristics of OTs in near real time. Using a combination of reanalysis data, observed rawinsonde data, and geostationary satellite observations, the LMS thermodynamic environment and observed OT characteristics are quantified and compared. Results show relationships between multiple measures of atmospheric stability and observed OT characteristics, including a direct relationship between OT depth and LMS temperature lapse rate. Idealized model simulations will be used to help interpret these relationships.

ORAL | POSTER

Physical-Chemical Characterization of Hailstones Collected near Córdoba, Argentina

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Córdoba Province in central Argentina is a region with the most severe storms in the world. With frequent hailstorms, there is still a challenge in forecasting hail because of the incomplete understanding of environmental and storm internal controls. This study provides a physical-chemical analysis of a 4 cm hailstone collected on 8 February 2018 through the citizen science program “Cosecheros de Granizo”, including non-soluble particles contained within. Previous studies show that a particle’s biological or inorganic composition affects the temperature at which hail embryos form in the cloud. This project studies the particle size distribution, particle elemental chemical composition, and particle angularity to identify possible source regions from which these particles were transported to further our understanding of hail formation in this region.

Approximately 90 non-soluble particles were identified in a hail sample from the 8 February supercell to determine if those particles are organic or inorganic and investigate the particle surface distribution in each sample. Thin samples of sublimated ice were analyzed under a Laser Confocal Scanning Microscope to create a 2-D map along an axis in the equatorial plane of hail samples to identify particles to further analyze for size and topography information. The samples were then gold-coated in a high vacuum to be analyzed with a Scanning Electron Microprobe, taking backscattered electron imagery and using energy dispersive spectroscopy to obtain the chemical element present in the particles of the hail. Particle size distribution in this sample ranges from 20 to 60 µm, which is larger than reported in an environmental analysis from the CACTI Field Project (0.5 to 20 µm). 91% of particles found in this hail stone contained carbon ranging from 38 to 66% of the molecular weight found in particles. This presentation will also discuss angularity results and future work with additional hail samples.

Numerical Simulations of Cloud Droplet Temperatures in Sub-saturated Environments

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Given the importance of cloud droplet temperatures in basic cloud microphysical and radiative processes – especially ice nucleation, this study investigates the relationships between the evolution of an evaporating droplet temperature and a broad range of environmental variables like relative humidity and ambient temperature, and droplet characteristics, including initial droplet radius. We present a detailed analysis of equilibrium temperatures (Teq) of cloud droplets, along with the time required to reach Teq, after being suddenly introduced to a new environment, under different conditions (both idealized and realistic), considering key heat and mass transfer physical mechanisms. This analysis shows that bulk evaporating droplets can exist at up to temperatures 10 degrees cooler than their environment, under certain conditions. The time required to reach Teq is directly proportional to the initial droplet radius. The decrease in droplet temperature is directly proportional to the ambient temperature and inversely proportional to the ambient relative humidity. Also, larger droplets can potentially further enhance ice nucleation as they can exist at a colder temperature for a longer time. These results can help improve our understanding of the primary ice nucleation mechanisms and potentially lead to more robust ice parameterization schemes in existing numerical models.

ORAL | POSTER

Kinematic Modeling Study of the Re-Organization of Snowfall beneath Cloud-top Generating Cells in Midlatitude Cyclones

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While past research of midlatitude winter extratropical cyclones has investigated and observed both near-surface precipitation banding features and cloud top generating cells within the comma head region of such storms separately, little is known about the relationship between the two. The purpose of this work is to assess impact of 2-D kinematic flow on the re-organization of falling ice particles beneath cloud-top generating cells in storms with low-level snow bands.

Three cases with different low-level snow band structures were chosen: one exhibiting a single snow band, one exhibiting multi-banded snow band structure, and one exhibiting a transition from a convective precipitation region to multi-band snow band structure. In each case, cross-sections were drawn normal to the long axis of the band(s) on the surveillance radar plots. Tangential winds were calculated along each cross-section. Ice particles, spanning the entire length of the cross-section, spaced 10 m apart, were initialized at either 6, 8, 10 km, or all three altitudes simultaneously, and descended to near the surface with fall velocities of either 0.8, 0.9, 1.0, 1.1, or 1.2 m s-1. Histograms of particle concentration, with 10 km wide bins, show the distribution of ice particles near the surface for all simulations. For each case, ice particle maxima were collocated near the band(s) on the surveillance radar plots.

Future research will use 3-D kinematic flow to test ice particle re-organization beneath cloud-top generating cells in IMPACTS cases with both cloud-top generating cells and low-level bands present.